This Presentation is UNCLASSIFIED.

the Paradox of Diversity:
Fragility and Resiliency in the NETWORK

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Cryptologic Legacy
1952 to Today

the Code makers and the Code breakers

Suffer from Will Roger's disease

We never met a network or computer we "dident" like .

Information Superiority for the Nation

If it **communicates** or it **computes**,

we care about it!

The **NETWORK** is at the **CENTER**

- the 'glue' that holds everything together.

We help to defend not only your Information but your Ability to Act on that information.

NETWORK:
a Vast Complex System

- ***ALL*** *that communicates and computes -*
  infrastructure/policy/practice *that put it into place and* ***people*** *who use it*
- *A gigantic collection of connected*
  independent, interdependent, interacting *networks with little to no centralized control !!*
- *Arguably the* ***most complex system*** *so far created by man*
- *Both engineered and natural*
- *Becoming an indispensable* ***MATURE*** *'utility' for much of mankind*

PHYSICAL LAYERS—SEEING IS DECEIVING

What we see is…Geography, Technology, and People

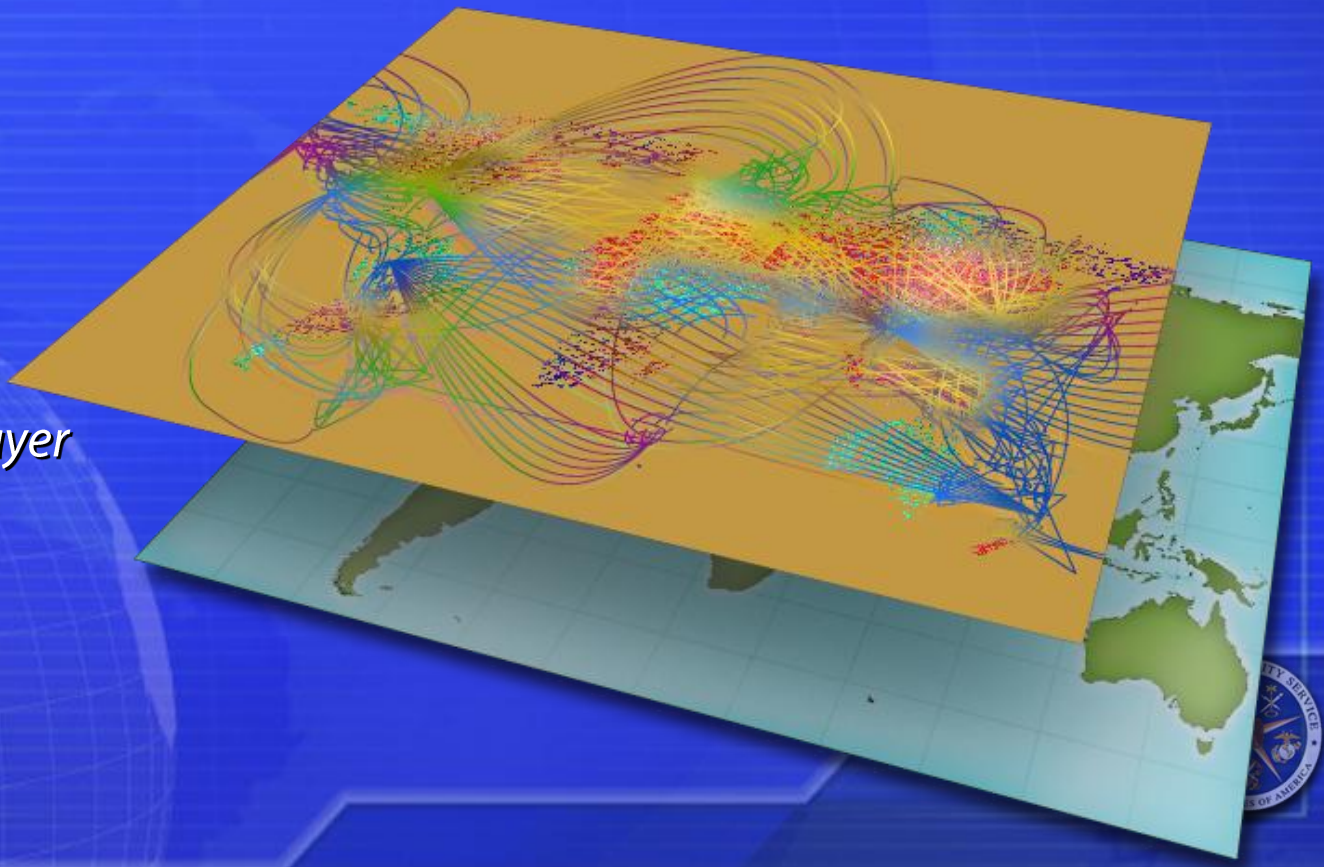
World View

Geography: our presence on the earth, the anchor point where you are located when you live, work, and play in cyberspace.
Technology: Blackberries, cell phones, and computers.
People: One person can have access to many pieces of technology – a desktop computer and Blackberry at work, and a laptop and cell phone at home.

UNDERSTANDING CYBERSPACE

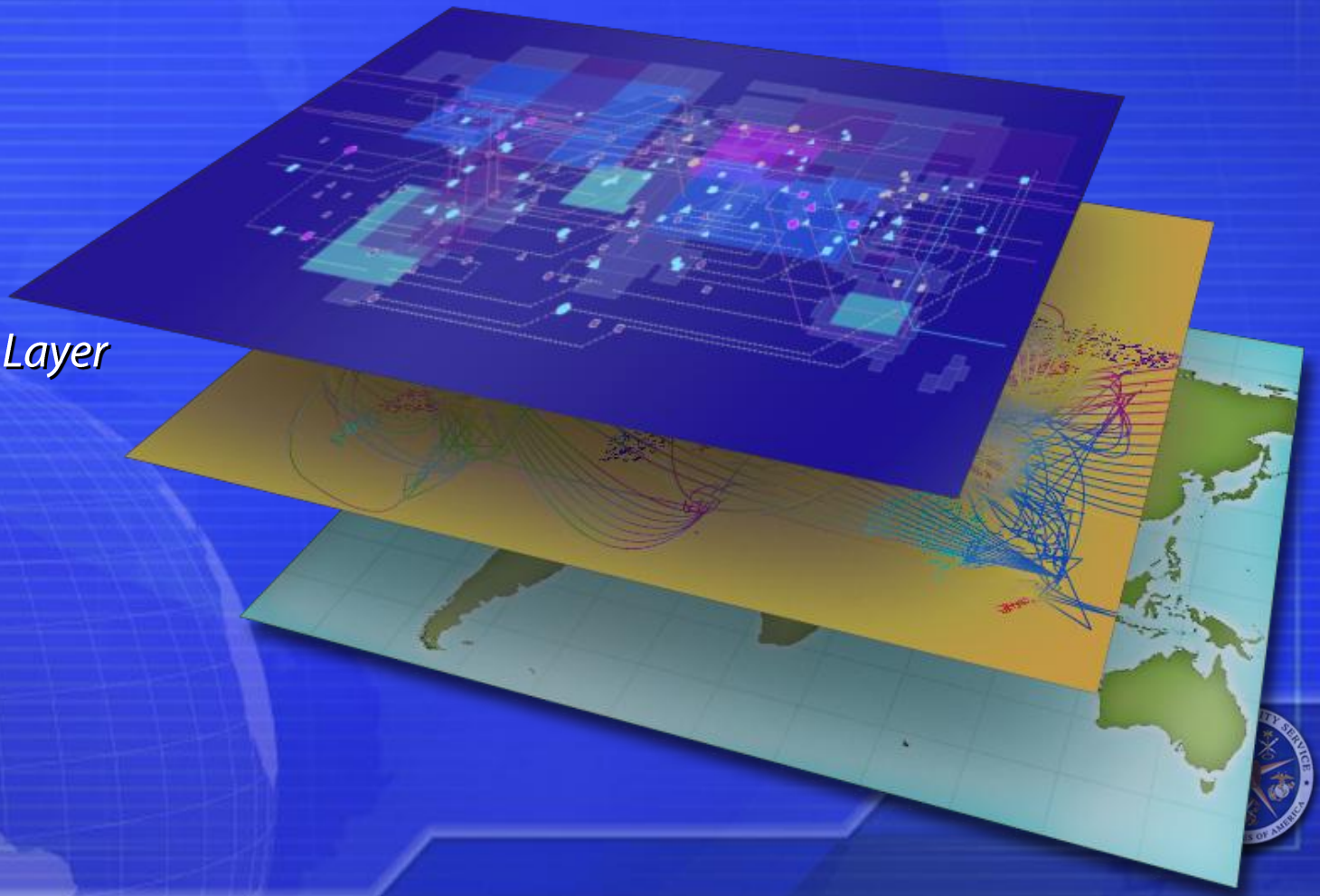
Geographic Layer

UNDERSTANDING CYBERSPACE



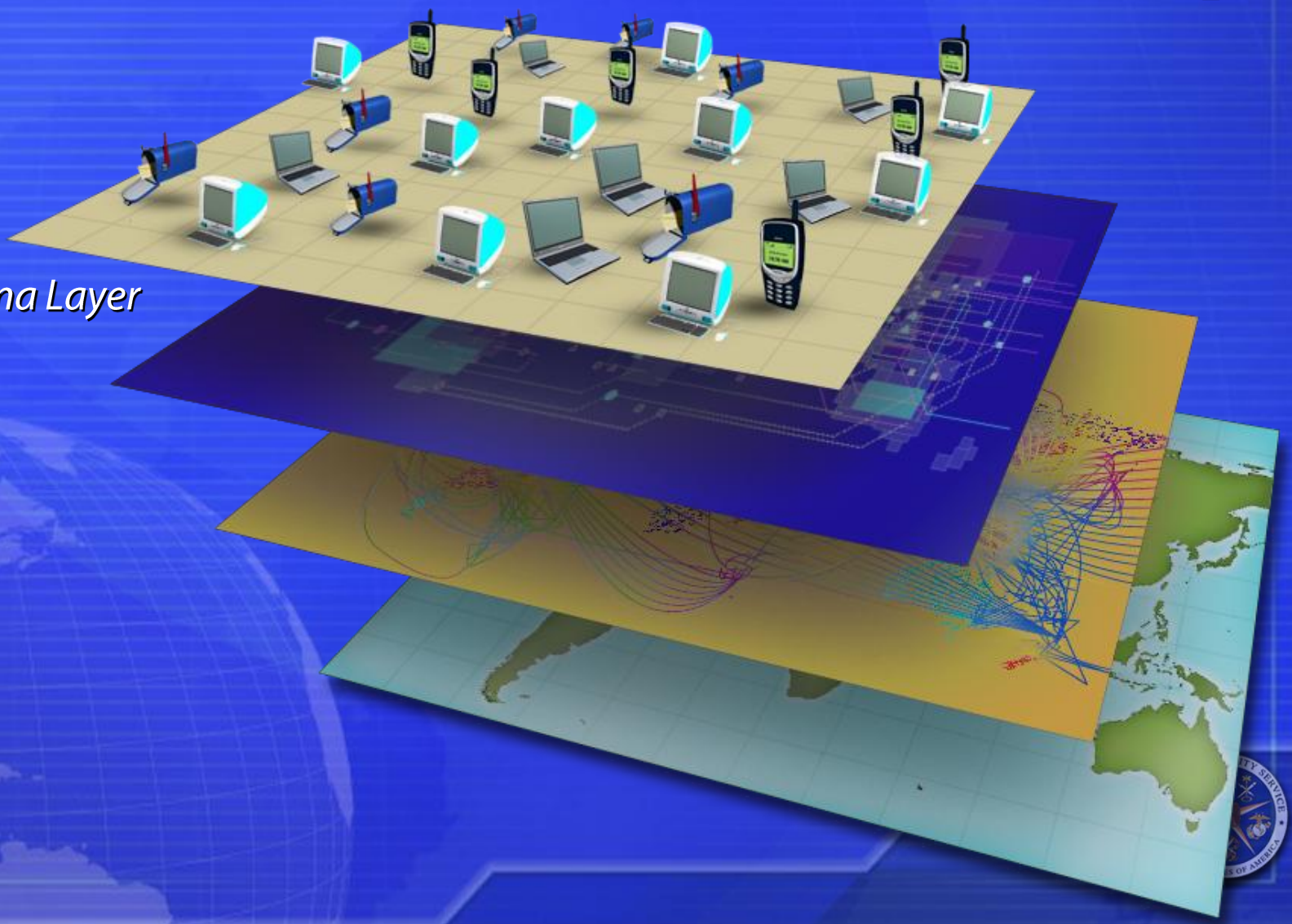
Physical Network Layer

UNDERSTANDING CYBERSPACE

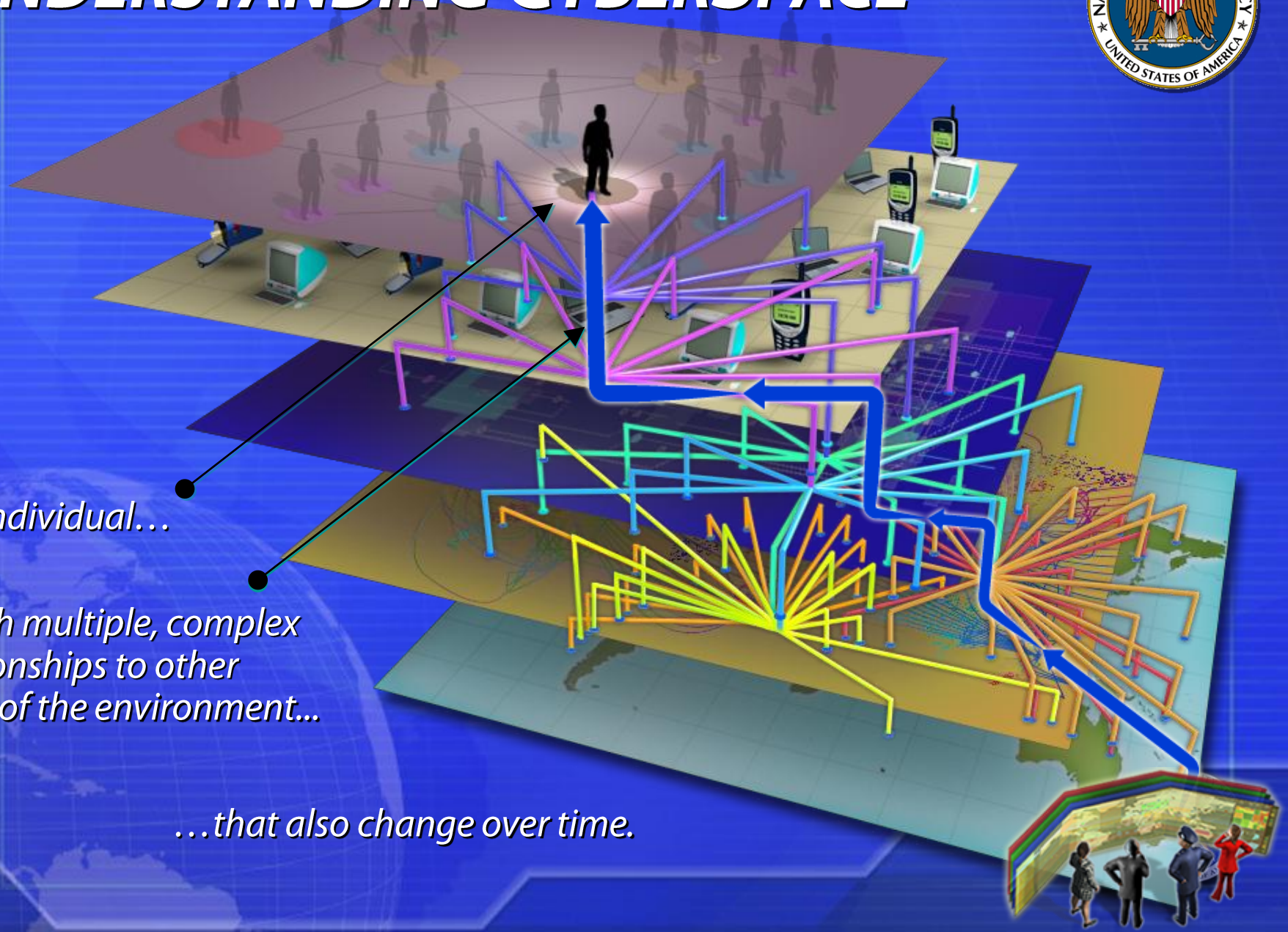


Logical Network Layer

UNDERSTANDING CYBERSPACE



UNDERSTANDING CYBERSPACE



One individual…

…with multiple, complex relationships to other levels of the environment...

…that also change over time.

Designed ?

NETWORK *- an incredibly complex melding of*
the ***intended*** *with*
the ***unintended*** **,**

a vast 'kluge' with both
designed *and*
emergent
properties

easy to ***injure*** *!*

impossible to ***kill*** *!!*

the ***NETWORK*** *gives birth to*

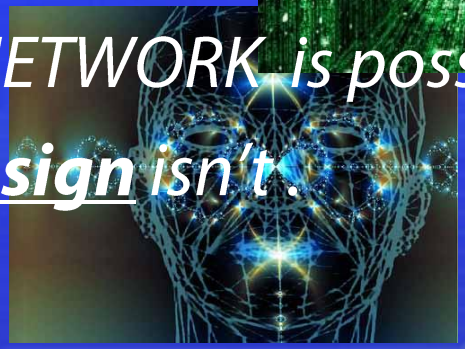
CyberSpace

- *Where is* ***CyberSpace****?*
  Everywhere and Nowhere!
  Distance Disappears !
  "VIRTUAL" *dimensions transcend space and time.*
  Time Shortens !!
- *What happens there?*
  EVERYTHING becomes ***HERE*** *and* ***NOW*** *!!!*
  All dimensions ***compress*** *!!*

The Challenge:

Keeping CYBERSPACE safe, secure and shared when . . .

- *"Everything that can go **digital**, **Will**!"*
- *"Everything that can be **connected**, **Will be**!"*
- *NO ONE really owns or **controls** the NETWORK - the connection fabric.*
- *Local design of the NETWORK is possible, but Global **re-design** isn't.*



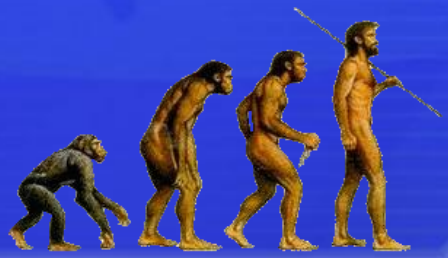
The Message:

*What makes the **NETWORK** Fragile also keeps it Resilient.*

*Understanding **WHY** this is so may help us "tilt the table" in favor of its Resiliency at the expense of its Fragility.*

*in the **NETWORK** Biological Metaphors become **REAL!***

Lessons from Biology and Evolution should inform the way we design and control those parts which we can.



4 Lessons from Evolution

- ***Monocultures are weak.*** *What kills one, can kill ALL.*
- ***Polycultures are strong.*** *Some fraction always manages to survive!*
- *Polyculture emerges from* ***Diversity*** *.*
- ***Randomness,*** *rather than mere variation, contributes 'near'* ***optimal*** *solutions .*

Implications from the Lessons

- ***A Monoculture is BAD, but…***

  a ***Networked*** *Monoculture is* ***AWFUL*** *!!*

  A threat to one becomes a threat to all.

  *(****redundancy does not imply resilience*** *– It just takes a little longer for them all to DIE).*

- *Randomness is an* ***Essential*** *Feature*

  Polycultures arising from 'random' variations tend to survive assaults by both humans and mother nature because neither can ***use*** *their* ***'design decisions' against them*** *!*

- ***Resiliency ≠ Reliability***

  Resilient systems can fall over so long as they stand back up quickly/easily without disruption while reliable (dependable) systems shouldn't fall over at all. ***Failure in some part of the system is the Norm rather than the Exception*** *!*

- ***Reliability*** *demands* ***Discipline***

  Nonconforming ***incompatibilities*** *don't work well together,* ***cause failures***

- ***Discipline*** *deplores* ***Diversity***

  Efficiency requires Discipline*, Diversity resists it.*

  Discipline seems essential to 'Network' well together.

- ***Diversity*** *may cause* ***Unreliability***

  Wide variation admits ***many failure modes****. Something is always going wrong somewhere; some part of the system is* ***always down****.*

- ***Ultra-efficient*** *=* ***Rigid*** *(i.e., Brittle)*

  Wringing out all inefficiency requires enforcing rigid discipline thus eliminating Diversity which in turn creates a monoculture introducing brittleness into the system .

  (What breaks one, breaks all).

- ***Randomness*** *requires* ***Unpredictability***

  Unpredictability *confers as much* ***strength*** *as it does* ***weakness*** *to a complex system - while we can't always count on things, it foils "adversaries" and provides a useful tool for efficient computation and operations.*

  (Statistical modes take over!)

- ***People*** *are an actual* ***PART*** *of the System (NETWORK) not just its* ***"users."***

  The NETWORK has already begun to evidence characteristics of a biological system. It will behave more and more like an "organism" as we humans "join" with it physically as well as figuratively!

Limitations to the Lessons of Biology and Evolution

- *"You can't get **there** from here!"*
  - *There are **optimal** solutions to which there are NO "evolutionary" paths.*
  - *Too "far" away from the current state*
- *Evolution only needs some source of variation to proceed.*
  - *Randomness (unpredictability) isn't required.*
  - *Evolutionary solutions may NOT be optimal.*

"Tilting the Table"

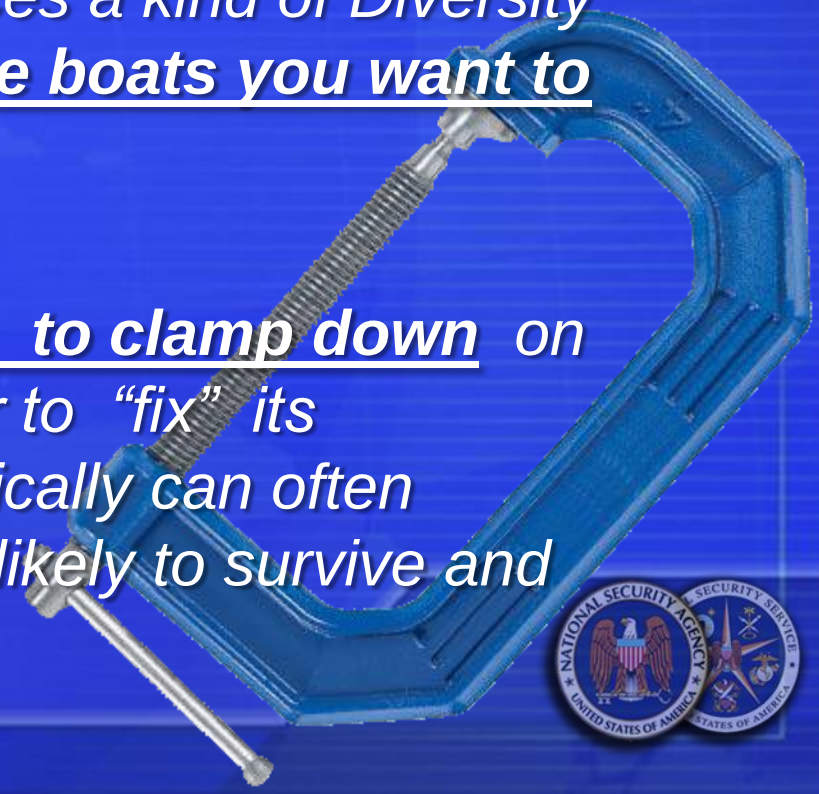
- *Can't just raise/lower the 'Tide of Diversity'*
  *At best will make system **more** resilient but*
  ***more** fragile, or*
  ***Less** fragile but **less** resilient -*

Either way solves only <u>half</u> the problem!

Splitting the Horns of the Dilemma

- *Incorporating 'disciplined' Randomness as a design feature introduces a kind of Diversity that can* ***lift just those boats you want to lift*** *.*

- ***Resisting the temptation to clamp down*** *on a NETWORK in order to "fix" its vulnerabilities paradoxically can often actually make it more likely to survive and to recover.*



The IDEA:

- *Design for the same ‘functionality’ not for the same component !*
- *Diverse components exhibit different failure/recovery modes.*
- *When you “**don’t** put all your eggs in one basket,” your . . . .*

Diversity *keeps your adversaries*

Accidents,

Mistakes,

Mother Nature, or

True malefactors

having to play "whack-a-mole"

with ***different*** ***Mallets*** *!!!!*

Message

Diversity in the NETWORK often Cures more Ills than it Creates .

While it makes the NETWORK vulnerable, it gives the NETWORK real Resilience.

Thanks for Listening

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